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(54) Control and method for electric water heater operation

(57) A control and method for preventing dry start of an electric water heater provides activation of a bottom heating element for a short time and then senses the temperature to detect the absence or presence of water around the bottom heating element. In the absence of water, the control prevents further activation of the heating element. If water is present, the bottom heating element is activated to heat the water to a set point temperature. An additional upper heating element is activatable only after its temperature falls a predetermined amount below the set point temperature. The control may also include a programmable time having the ability to vary the turn off set point temperature in a predetermined manner during different times of a given day and/or week as well as to provide a convenient way to maintain a reduced turn off set point temperature for an extended period of time.

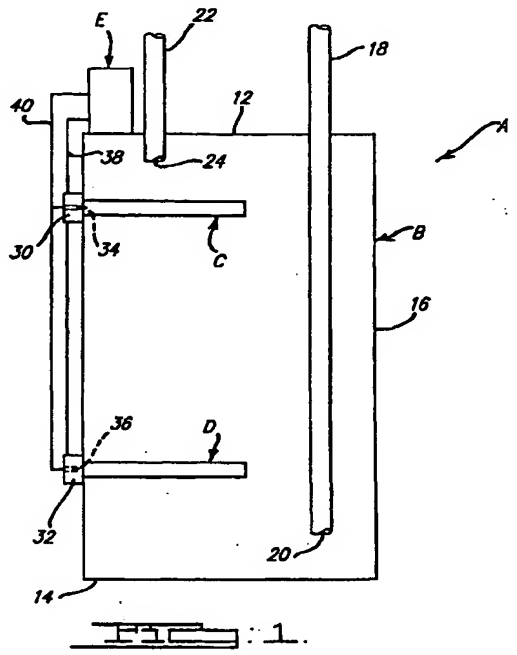

Fig. 1.

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Description

[0001] This application relates to the art of controls and methods for operating electric water heaters. The invention is particularly applicable to a control and method that uses a micro controller and will be described with specific reference thereto. However, it will be appreciated that the invention has broader aspects and can be carried out with other types of controls.

[0002] When an electric water heater is installed, it is desirable to fill the water heater tank with water and purge the tank of air before the heater is turned on. Failure to fill the water beater tank with water and purge any air may result in damage to the heating elements or the water heater. Therefore, it would be desirable to have an automatic arrangement for preventing operation of the heating elements in the absence of water in the water heater tank. Additionally, it would be desirable to incorporate additional energy saving features such as enabling programming of the water heater to accommodate variations in time of day and/or day of week hot water demand cycles as well as to offer a convenient and easy to use vacation temperature set back feature.

[0003] A control and method for detecting a dry start in an electric water heater having a single or dual top and bottom electric heating elements or additional heating elements operates by first recording the initial temperature at the single or bottom most heating element. The single or bottom most heating element then is activated for a short period of time followed by deactivation and a delay after which the final temperature at the bottom most heating element is recorded. The initial and final temperature readings are then compared and if the difference therebetween is greater than several degrees, it indicates that the single or bottom most heating element is not submerged in water and the control locks all the heating elements off so as to prevent further energization of the heating elements until the controller is reset.

[0004] If the difference between the initial and subsequent temperature is less than a few degrees, there is confirmation that the bottom heating element is surrounded by water and the bottom heating element is then activated for heating the water to a turn off set point temperature.

[0005] The temperature at the top heating element is monitored and the control enables activation of the top heating element only after the temperature at the top heating element has reached the turn off set point temperature and then falls several degrees below the turn off set point temperature. This prevents activation of the top heating element in the event the water heater tank has not been purged of air and hence the top heating element has not been submerged in water.

[0006] The controller may also incorporate features to enable the set point temperature (the temperature at which the heating element is deenergized) to be varied either at various times during the day and/or for different days of the week so as to accommodate hot water use patterns while reducing the overall energy consumption of the water heater as well as to provide a vacation setting during which a reduced set point is maintained over an extended period of time thus offering the consumer a convenient, easy to use means for conserving energy consumption.

[0007] Additional advantages and features of the present invention will become apparent from the subsequent description of a preferred embodiment of the invention taken in conjunction with the accompanying drawings, in which:

Figure 1 is a diagrammatic illustration of an electric water heater that is operated in accordance with the control and method of the present application;
Figures 2 and 2A illustrate flow charts of the operation of an electric water heater in accordance with the control and method of the present invention;
Figure 3 is a circuit diagram of a control in accordance with the present invention; and
Figure 4 is a view showing an optional programmable timer interconnected with a control, all in accordance with the present invention.

[0008] Referring now to the drawings, wherein the showings are for purposes of illustrating a preferred embodiment of the invention only and not for purposes of limiting same, Figure 1 shows an electric water heater A that includes a water tank B having a top wall 12, a bottom wall 14 and a peripheral or side wall 16.

[0009] A cold water supply pipe 18 enters tank B through top wall 12 thereof and has an inlet 20 located adjacent tank bottom wall 14 so that cold water enters tank B adjacent the bottom thereof. A hot water discharge pipe 22 extends into tank B through top wall 12 thereof and has an inlet 24 located adjacent top wall 12 through which hot water is discharged from tank B.

[0010] Top and bottom electric heating elements C, D extend into tank B through side wall 16 thereof and are secured to side wall 16 in a known manner. Each heating element C, D has a base 30, 32 located externally of tank side wall 16. Each base has suitable terminals thereon for connecting wires thereto and a temperature sensor such as a thermistor 35, 36 having a negative temperature coefficient of resistance is received in each base for providing temperature signals.

[0011] It should be noted that the present invenition is being described in connection with a water heater employing dual heating elements, that is upper and lower heating elements C and D. However, it may also be incorporated in water heaters utilizing only a single heating element if desired or a heater having more than two such heating elements.

[0012] A control E is shown mounted at the top of electric water heater A although it will be appreciated that other mounting locations also are possible. Control

E is connectable with an AC power source in a known manner, and wires 38, 40 are shown diagrammatically for connecting heating elements C, D to the power source through control E and for connecting thermistors 34, 36 with control E.

[0013] When a water heater is initially installed or is being returned to service after having had the water drained from the holding tank, the tank will contain a volume of air at atmospheric pressure. As the water supply valve is opened, water will flow into the tank until the internal pressure within the tank is equal to the pressure of the water supply. However, if the outlet valve is closed or if none of the hot water dispensing valves are opened, the air in the tank will be trapped and compressed to a pressure equal to that of the water supply pressure. This compressed air if not released will limit the filling of the tank with water such that one or both heating elements may be not submerged in water. Because water is a much better heat sink than air, energization of a heating element when it is not submerged in water may result in damage to the heater element. This condition is commonly referred to as a dry start condition meaning that a heating element is energized before it is submerged in water.

[0014] Referring now to Figure 2, after the water heater has been installed and the appropriate electrical and water connections completed, control E is turned on to initiate operation as indicated at 50. Control E then records an initial temperature monitored by thermistor 36 at bottom heating element D as indicated at 52. Bottom heating element D then is activated for a predetermined time period followed by deactivation for a predetermined delay time as indicated at 54. Following the delay, control E again records a final temperature monitored by thermistor 36 at bottom heating element D as indicated at 56. The difference between the initial and final temperatures is then calculated as indicated at 58.

[0015] As indicated at 60 in Figure 2A, a difference greater than a predetermined number of degrees between the initial and final temperature means that there has been a dry start and that the bottom heating element is not surrounded by water. If the difference between the initial and final temperature is less than the predetermined number of degrees, it means that the bottom heating element is submerged in water and operation of the water heater may proceed in the normal manner. With water present, the bottom heating element is activated as indicated at 62 for heating water in the tank to a turn off set point temperature as determined by a manually operable selector switch indicated at 64. The bottom heating element cycles or remains on until the turn off set point temperature is reached. Bottom heating element D will then be deenergized by control E. As the hot water cools due to heat loss through the housing or is drawn from the top of the hot water tank through discharge pipe 22 and additional cold water flows into the tank B through inlet 20, the temperature sensed by thermistor 36 will drop below the turn on set point temperature. At a predetermined turn on set point temperature, control E will reenergize lower heating element which will typically be on the order of 5-10 degrees below the turn off set point temperature to again heat the water in tank B up to the turn off set point temperature. This operation cycle will then continue in this sequence for normal operation.

[0016] As the lower heating element D heats the water in tank B, normal convention current will cause it to rise thus increasing the temperature sensed by the upper thermistor 34. Eventually, the temperature sensed by thermistor 34 at top heating element C will reach the turn off set point temperature but only if top heating element C is or becomes submerge in the water. If top heating element C is surrounded by an air bubble in tank B, activation of top heating element C is undesirable and control E will prevent it from being energized. However, if the upper heating element is submerged in water, control E will record that thermistor 34 has reached the turn off set point temperature. When the temperature sensed by thermistor 34 falls a predetermined number of degrees below the turn off set point temperature as a result of use of hot water or normal cooling of the water, control E will enable normal operation of the upper heating element. Therefore, the control will activate top heating element C only after the temperature monitored by top thermistor 34 falls a predetermined number of degrees below the set point temperature. Thereafter, both the top and bottom heating elements may cycle individually but generally not simultaneously for maintaining the set point temperature. These operational steps are indicated at 66 and 68 in Figure 2A. However, should for some reason the turn off set point temperature be set below a predetermined minimum, it is possible that the hot water heated by lower heating element D may increase the temperature of the air pocket being sensed by upper thermistor 34 sufficiently to reach the turn off set point even though the upper heating element is not submerged. In order to prevent this occurrence, control E will not operate to initiate the routine described above to allow for energization of the upper heating element if the turn off set point temperature is below a predetermined minimum, such as for example below 110° F.

[0017] As noted above, most water heaters designed for residential use have dual heating elements and control E will be designed to enable operation of one or the other of heating elements C or D but generally not both simultaneously. In these water heaters, lower element D will normally be cycled on and off in response to demand. However, should there be a sufficiently high demand that the temperature sensed by upper thermistor 34 is reduced to the turn on set point, lower heating element D will be deenergized and upper heating element C will be energized until such time as the turn off set point is reached. However, other types of water heaters may allow for simultaneous operation of

both heating elements or even more than two heating elements. The present invention is equally useful with such water heaters, it being understood that the same sequence for enabling initial energization of the lower most and then the upper most heating elements by control E as described above with respect to elements C and D will be followed. It should be noted that while it is possible to design control E such that it will sequentially enable energization of each successively higher mounted heating element if desired, this is generally not believed necessary because once the top most heating element has been submerged in water, all of the other lower heating elements will also have been submerged.

[0018] In the event that a dry start is detected at step 60 in Figure 2A, the control operates to deenergize lower heating element D and thereafter will prevent energization of both heating elements C and D as indicated at 70. After filling the water heater tank with water and purging it of air, the control may be reset and reactivated as indicate at 72 to do a restart from the step indicated at 50 in Figure 2.

[0019] In a presently preferred embodiment, control E will initially operate to energize lower heating element D for a period of about 5 seconds after the initial temperature of thermistor 36 has been recorded. Thereafter, it will operate to deenergize the lower heating element for a period of about two minutes after which the temperature sensed by lower thermistor 36 will again be recorded. If the difference between the first and second recorded temperatures is greater than 5° F., a dry start condition is indicated and further energization of both heating elements would be prevented until control E has been reset. It should be noted, however, that while the above time durations and temperatures are presently believed preferable, they may be varied depending upon the particular application for which the present inveniton is to be used. For example, if a lower wattage heating element is used, it may be desirable to increase the energization time duration and likewise higher wattage heating elements may require a shorter on time.

[0020] With reference to Figure 3, an AC to DC converter and DC power supply is indicated at 80. A micro controller F controls operation of upper and lower heating elements C, D in accordance with the present application. The circuit includes four power transistors 82-85 connected with four relays 92-95. Relays 92-94 are normally open while relay 95 is normally closed. Relays 92 and 93 respectively are connected with upper and lower heating elements C, D, and relays 94, 95 are limit relays. Comparators 102, 104 are provided for turning transistors 84, 85 on or off to control limit relays 94, 95. A selector switch 110 is provided for selecting a desired set point temperature for the water in the water heater. A transistor 112 flashes LED 114 in accordance with signals from micro controller F when fault conditions exist.

[0021] When the control initially is turned on or plugged in, the output of comparator 102 is low so that transistor 85 remains off and limit relay 95 remains closed. At the same time, the normal steady state output of comparator 104 is high so that transistor 84 is turned on to energize and close limit relay 94.

[0022] When the control initially is turned on or plugged in, thermistors 34, 36 provide constant temperature signals to micro controller F which records an initial temperature at the bottom heating element from bottom thermistor 36. Micro controller F then turns on transistor 83 to energize and close relay 93 for a short period of time such as around five seconds. This activates lower heating element D through relays 95, 93 and 94. Following the short time period, micro controller F turns transistor 83 off to deenergize and open relay 93 for deactivating lower heating element D.

[0023] After lower heating element D is turned off, there is a delay of around two minutes at the end of which micro controller F records a final temperature from thermistor 36 at the bottom heating element. Micro controller F then compares the initial and final temperatures. If the difference is more than a predetermined number of degrees, it indicates that there has been a dry start and the lower heating element is not submerged in water. Therefore, micro controller F will lock all the heating elements off so as to prevent further operation of the heating elements. An appropriate visual and/or audible alarm may also be provided on control E to indicate this condition.

[0024] In the event there is water in the tank, the difference between the initial and final temperature will be less than the predetermined number of degrees and micro controller F will again turn transistor 83 on to close relay 93 and reactivate lower heating element D. Lower heating element D will be activated until the temperature signal received by micro controller F from bottom thermistor 36 corresponds to the desired turn off set point temperature that has been selected with selector switch 110. When the turn off set point is reached, micro controller F turns transistor 83 off to open relay 93 and deactivate lower heating element D.

[0025] Micro controller F receives constant readouts from thermistors 34, 36 to cycle the heating elements on and off for maintaining a desired water temperature in tank B. If there is an air bubble in the top of the tank, upper heating element C will not be submerged in water and it is undesirable to activate the top heating element under such conditions. Therefore, micro controller F will not enable activation of upper heating element C until the temperature signal provided by top thermistor 34 first reaches a temperature within a first predetermined number of degrees of the turn off set point temperature and thereafter falls a second predetermined number of degrees below the turn on set point temperature. These first and second predetermined numbers of degrees will preferably be about 3-5° F. although other numbers may be used and the two need not be equal. The temperature at the upper heating element will not fall that much unless it is or becomes sub-

merge in water. Until such time as the temperature at the top heating element falls at least several degrees below the set point temperature, micro controller F blocks or prevents activation of the top heating element. After the temperature falls the required number of degrees, micro controller F enables activation of the top heating element when subsequent signals from the thermistors call for activation of the top heating element.

[0026] Once the temperature at the upper heating element falls several degrees below the set point temperature, it will be activated depending on the demand for hot water and the temperature signals provided by thermistors 34, 36 to micro controller F. When the temperature signals provided to micro controller F indicate that the temperature has not fallen drastically below the desired set point temperature, micro controller F may cycle bottom heating element D for bringing the water back up to the set point temperature and maintaining it. When the temperature signals indicate that the temperature has fallen dramatically below the desired set point temperature, micro controller F will activate only upper heating element C for reheating the water that will be drawn first from the tank. Thus, micro controller F will turn transistor 82 on to energize and close relay 92. This activates upper heating element C through limit relay 95, relay 92 and relay 94. When the set point temperature of the water in the upper portion of the tank is reached, micro controller F will deactivate top heating element C and may activate bottom heating element D.

[0027] Micro controller F is programmed to respond to excessive temperature signals from thermistors 34, 36. In the event thermistors 34,36 provide signals to micro controller F indicative of an excessive temperature, micro controller F will turn transistors 82, 93 off to open relays 92, 93 and deactivate the heating elements until such time as it is reset.

[0028] In the event micro controller F does not deactivate the heating elements in response to excessive temperature signals provided by thermistors 34, 36, the excessive temperature signal from top thermistor 34 will cause the output of comparator 102 to go high which turns transistor 82 on for energizing and opening normally closed relay 95. At the same time, the output of comparator 102 going high causes the output of comparator 104 to go low which turns transistor 84 off and opens relay 94. Thus, opening of relays 94, 95 will deactivate the heating elements until control E is reset in the event the operation of relays 92, 93 fails to do so.

[0029] When a dry start is detected, micro controller F pulses transistor 112 on and off to cause LED to blink once at intervals. Micro controller F may pulse transistor 112 on and off in different patterns or intervals to cause LED 114 to blink at different rates for indicating other malfunctions such as an excessive temperature readout at the top or bottom heating elements.

[0030] Micro controller F functions as a timing device for initially turning the bottom heating element on for several seconds and then delaying for a few minutes before the final temperature reading is recorded. Micro controller F also functions as an actuator that activates and deactivates the heating elements by turning the transistors on or off to close or open relays in response to sensed temperature signals form thermistors 34, 36.

[0031] Additionally, it should be noted that control E will preferably be programmed to deenergize and prevent further energization of both upper and lower heating elements in the event either the upper or lower thermistor were to become shorted or either thermistor were to open circuit. Again, if desired, a suitable visual and/or audible alarm may be incorporated in control E to indicate the occurrence of such an event.

[0032] In order to utilize the present invention in connection with a water heater having only a single heating element, control E will be designed to only operate the start up sequence described above with respect to the lower heating element.

[0033] It should also be noted that while the present invention has been described in connection with thermistors 34 and 36 being positioned in the base of the respective heating elements, these sensors may be located anywhere on the tank B but in order to provide full advantage of the dry start protection feature, they should be located in close proximity to the respective heating elements. For example, the sensors could be clipped to the outwardly protruding spuds of the heating elements rather than placed in the base thereof. Further, while the present invention has been described utilizing thermistors for sensing the temperatures, other types of sensors could be utilized in place thereof.

[0034] As mentioned previously, control E may also incorporate the ability to enable the turn off set point temperature to be varied depending upon the time of day and/or day of the week as well as to incorporate the ability to maintain a temporary reduced turn on set point temperature for an extended period of time (i.e. vacation set back). This may be easily accomplished by providing a conventional programmable timer either integrated into control E or in the form of a separate assembly which may optionally be interconnected with control E. The programmable timer will cooperate with the control E to vary the turn on set point utilized by control E and may allow for switching between two or more turn on temperature set points one or more times a day in different sequences for each day of the week. Additionally, the programmable timer may allow a programmed lower turn off set point to be held for an extended period of time (i.e. vacation set back). Such programmable timers are well known in the art and hence a detailed description thereof is not included here, the only modification thereto required being to provide for the programming of the various turn on set point temperatures.

[0035] An exemplary programmable timer 200 is shown in Figure 4 in the form of an optional assembly that may be interconnected with control E by leads 202 and 204. As shown, programmable timer includes on/off switches 206 and a select/program switch 208. A dis-

play incorporated therein may display the time of day, day of the week and which of several operational modes has been selected. In the example shown, three off peak programs may be accommodated thus allowing for one program for Monday through Friday and separate programs for Saturday and Sunday as well as a vacation mode and a normal mode in which the programmable timer will not operate to vary the turn off set point.

[0036] Although the invention has been shown and described with reference to a preferred embodiment, it is obvious that equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification. The present inveniton includes all such equivalent alterations and modifications, and is limited only by the scope of the claims.

Claims

1. Apparatus for detecting a dry start of an electric water heater having an electric heating element comprising:

   a heating element control that initially activates said heating element;

   a temperature sensing device that senses the temperature at said heating element a predetermined time after actuation of said heating element to provide a final temperature reading; and

   said control disabling said heating element when said final temperature reading is a predetermined value that is indicative of the absence of water around said heating element.

2. The apparatus of claim 1 wherein said temperature sensing device senses the temperature at said heating element to provide an initial temperature reading when said heating element initially is activated; and

   said control disabling activation of said heating element when said final temperature reading is a predetermined amount greater than said initial temperature reading.

3. The apparatus of claim 2 wherein said temperature sensing device obtains said initial temperature reading prior to activation of said heating element.

4. The apparatus of claim 3 wherein said temperature sensing device obtains said final temperature reading subsequent to deactivation of said heating element.

5. The apparatus of claim 4 wherein said temperature sensing device obtains said final temperature reading at least one minute after deactivation of said heating element.

6. Apparatus for detecting a dry start of an electric water heater having a heating element comprising:

   a heating element control including a timing device that initially activates said heating element for a short period of time;

   a temperature sensing device that monitors the temperature at said heating element and provides a temperature signal to said control;

   said control being responsive to said temperature signal to reactivate said heating element when said heating element is surrounded by water; and

   said control being responsive to said temperature signal to prevent reactivation of said heating element when said heating element is surrounded by air.

7. The apparatus of claim 6 wherein said control reactivates said bottom heating element to heat water to a set point temperature;

   a top heating element in said water heater;

   a top temperature sensing device that monitors the temperature at said top heating element and provides a top temperature signal to said control;

   said control being responsive to said top temperature to enable activation of said top heating element only after said top heating element is surrounded by water.

8. The apparatus of claim 6 or 7, wherein said heating element control is operable to reactivate said heating element until such time as said temperature sensing device provides a temperature signal to said control indicating that the temperature of said water has reached a turn off set point temperature.

9. The apparatus of claim 8 wherein said heating element control includes a programmable timer, said programmable timer being programmable to vary said turn off set point temperature between high first and lower second temperatures at preselected times.

10. The apparatus of claim 9 wherein said preselected times include preselected times of day.

11. The apparatus of claim 10 wherein said preselected times of day vary for different days of a week.

12. The apparatus of claim 9, 10 or 11, wherein said programmable timer is operative to maintain said set point temperature at a temperature below said high first temperature for an extended period of time.

13. Apparatus for activating and preventing dry start of an electric water heater having top and bottom heating elements following initial installation of the water heater comprising:

a heating element control including a bottom heating element activator that activates said bottom heating element;
a bottom temperature sensing device that senses the temperature at said bottom heating element and provides a bottom temperature signal to said control;
said control being responsive to said bottom temperature signal to maintain activation of said bottom heating element when said bottom heating element is surrounded by water;
said control being responsive to said bottom temperature signal to disable said bottom heating element when said bottom heating element is surrounded by air;
said control upon detection of a temperature that confirms the presence water around said bottom heating element maintaining activation of said bottom heating element to heat the water to a set point temperature;
a top temperature sensing device that monitors the temperature at said top heating element and provides a top temperature signal;
said control being responsive to said top temperature signal to enable activation of said top heating element only after the temperature at said top heating element falls a predetermined amount below said set point temperature.

14. A method for detecting a dry start of an electric water heater having an electric heating element comprising the steps of:

initially activating said heating element;
sensing the temperature at said heating element a predetermined time after actuation of said heating element to provide a final temperature reading; and
disabling said heating element when said final temperature reading is a predetermine value that is indicative of the absence of water around said heating element.

15. The method of claim 14 wherein said step of initially activating said heating element is carried out by initially activating said heating element for a short period of time followed by deactivation thereof, said step of disabling said heating element being carried out by preventing reactivation thereof.

16. The method of claim 15 wherein said step of sensing the temperature at said heating element to provide said final temperature signal is carried out by sensing the temperature at said heating element subsequent to deactivation thereof following said short time period.

17. The method of claim 14, 15 or 16, wherein said step of sensing is temperature at said heating element is carried out by sensing the temperature prior to activation of said heating element to provide an initial temperature reading, said step of disabling said heating element being carried out by determining the difference between said initial and final temperature readings and disabling said beating element when the difference is a predetermined amount.

18. The method of claim 17 wherein said heating element is activated for an initial short time period followed by deactivation thereof, said step of sensing the temperature at said heating element to obtain a final temperature reading being carried out by sensing the temperature subsequent to deactivation of said heating element.

19. The method of claim 18 wherein said step of sensing the temperature at said heating element to obtain a final temperature reading is carried out after a predetermined time delay following deactivation of said heating element at the end of said initial short time period.

20. A method of detecting a dry start in an electric water heater having a bottom heating element comprising the steps of:

initially activating the bottom heating element for a short time period;
sensing the temperature at the bottom heating element at the end of the short time period to detect the presence of water by a low sensed temperature or the absence of water by a high sensed temperature; and
either reactivating the bottom heating element responsive to a low sensed temperature or preventing reactivation of the bottom heating element responsive to a high sensed temperature.

21. The method of claim 20 wherein the water heater includes a top heating element and said steps of either reactivating or preventing reactivation is carried out by reactivating said bottom heating element

responsive to a low sensed temperature to heat water in the water heater to a set point temperature.

22. A method of initially energizing an electric water heater following installation thereof, the water heater having top and bottom heating elements, comprising the steps of:

activating the bottom heating element for short time period;
sensing the temperature at the bottom heating element to detect the presence of water by a low sensed temperature or the absence of water by a high sensed temperature;
either reactivating the bottom heating element responsive to a low sense temperature or deactivating the bottom heating element responsive to a low sense temperature or deactivating the water heater responsive to a high sensed temperature;
heating water in the water heater to a set point temperature when the bottom heating element is reactivated responsive to a low sense temperature;
sensing the temperature at the top heating element; and
enabling activation of the top heating element only after the sensed temperature at the top heating element falls a predetermined amount below the set point temperature.

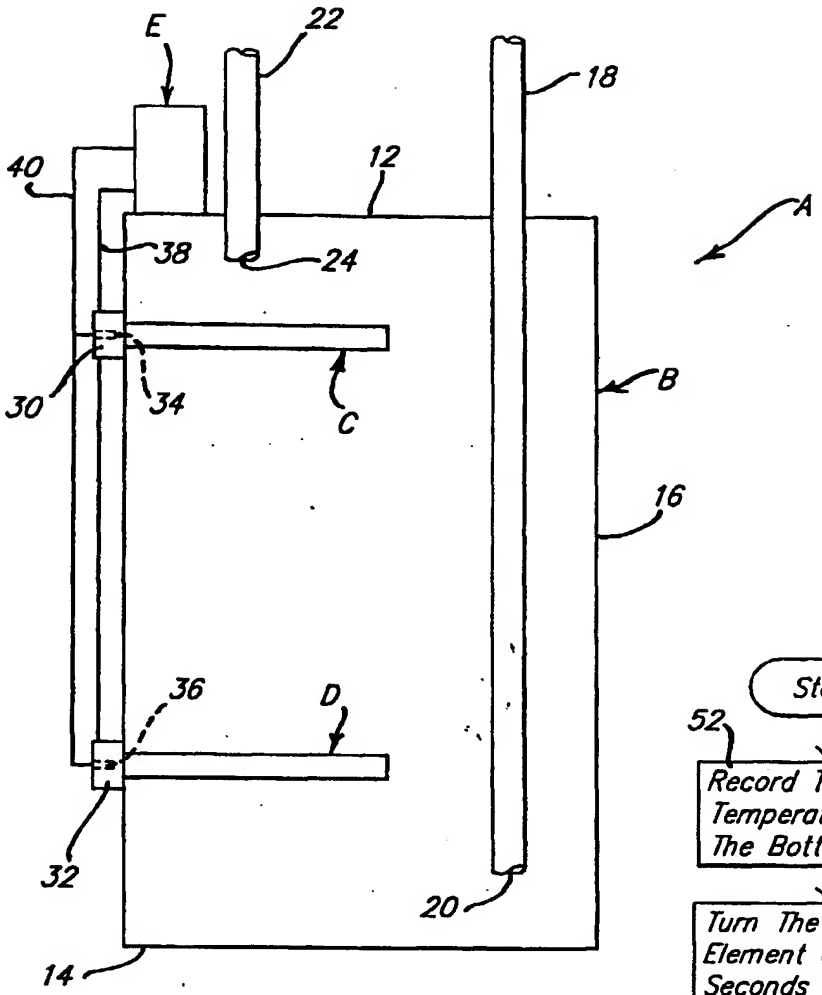

E
22
18
40
12
A
38
24
30
34
C
B
16
36
D
32
20
14

FIG. 1.

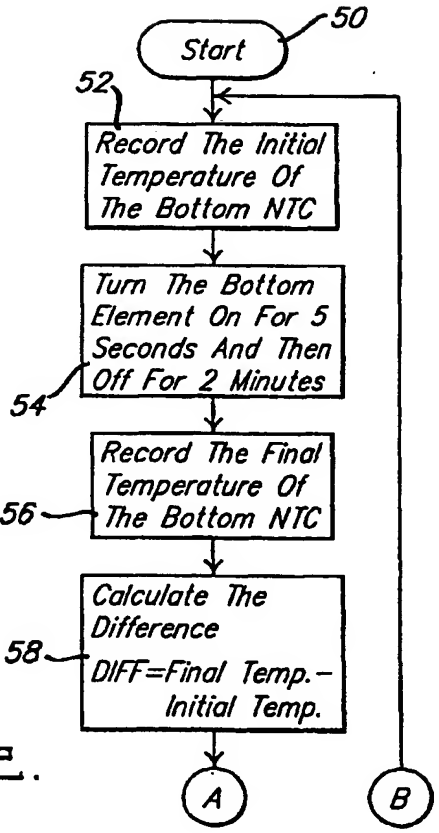

Start
50
52
Record The Initial Temperature Of The Bottom NTC
Turn The Bottom Element On For 5 Seconds And Then Off For 2 Minutes
54
Record The Final Temperature Of The Bottom NTC
56
Calculate The Difference
58
DIFF=Final Temp.- Initial Temp.
A
B

FIG. 2.

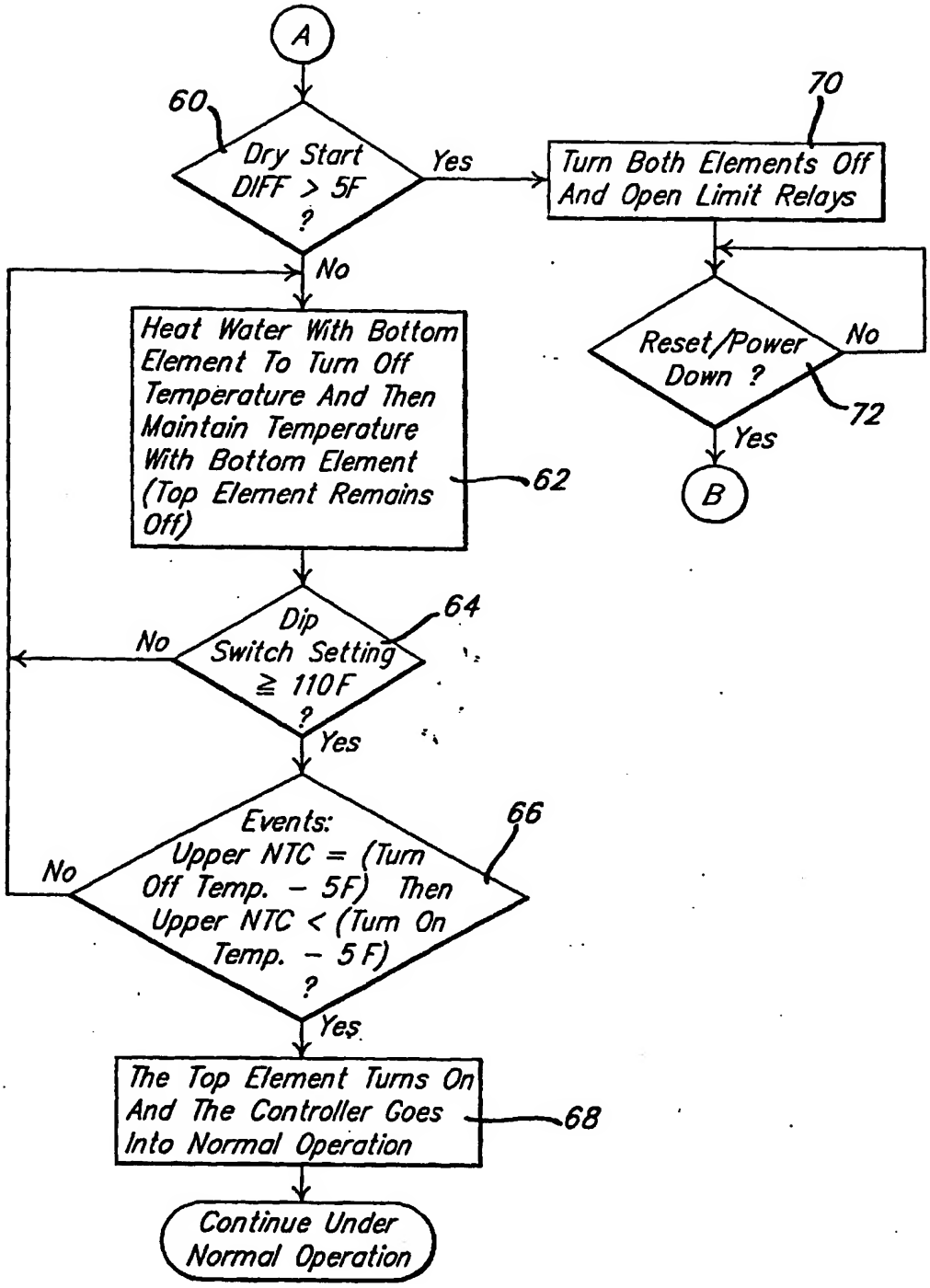
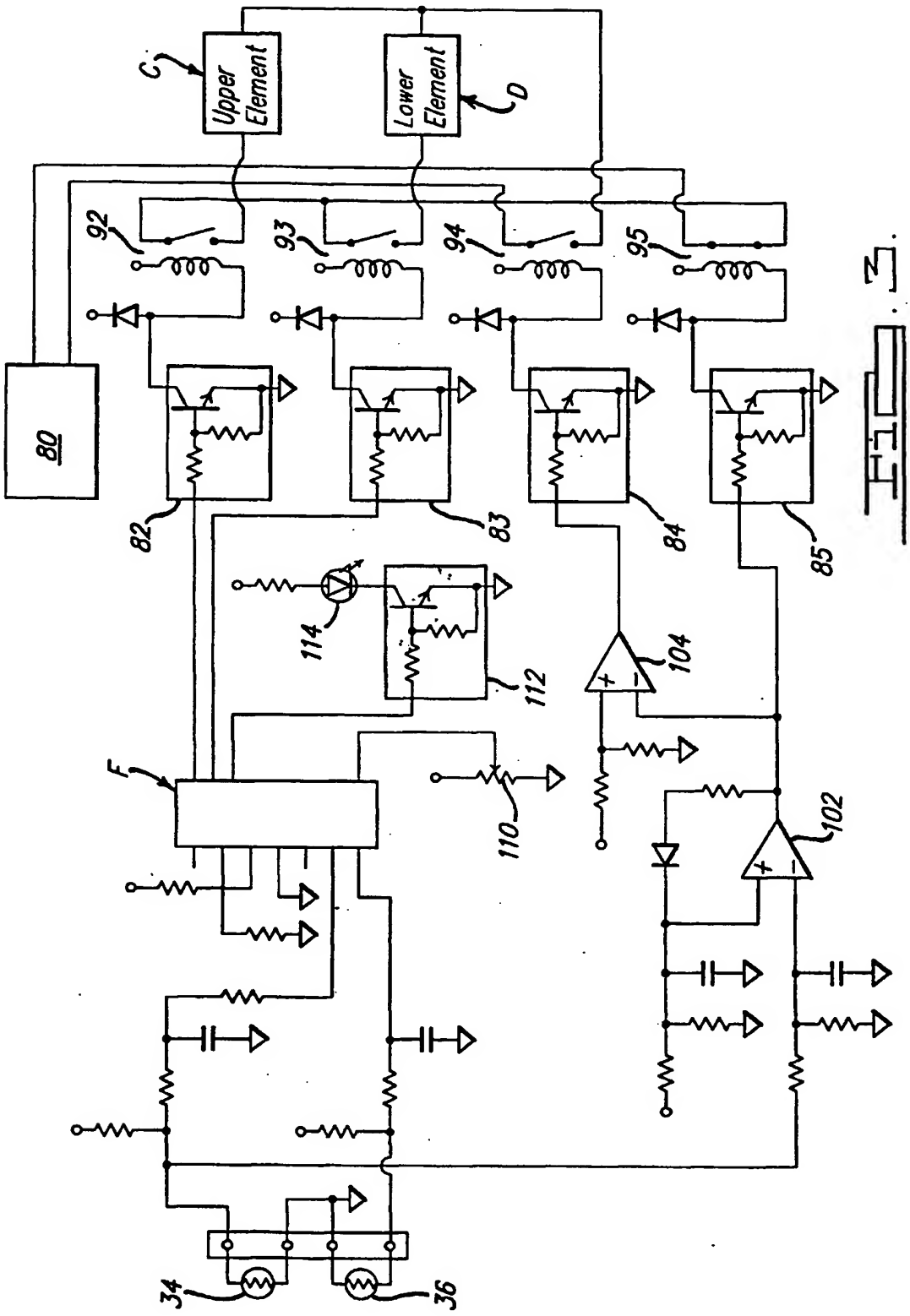
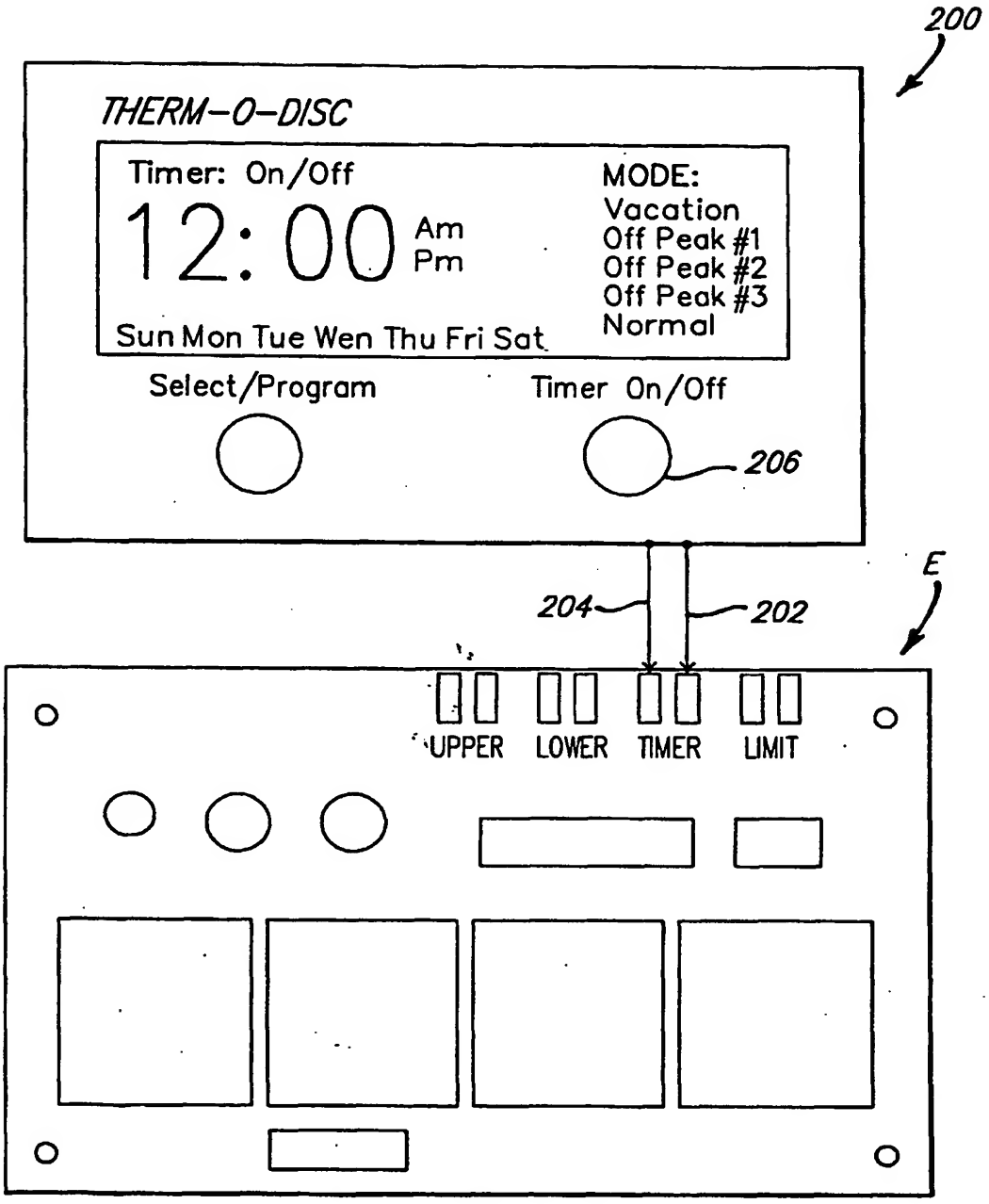

A
60
Dry Start DIFF > 5F ?
Yes
70
Turn Both Elements Off And Open Limit Relays
No
Reset/Power Down ?
No
72
Yes
B
Heat Water With Bottom Element To Turn Off Temperature And Then Maintain Temperature With Bottom Element (Top Element Remains Off)
62
Dip Switch Setting ≧ 110F ?
64
No
Yes
Events: Upper NTC = (Turn Off Temp. – 5F) Then Upper NTC < (Turn On Temp. – 5F) ?
66
No
Yes
The Top Element Turns On And The Controller Goes Into Normal Operation
68
Continue Under Normal Operation

FIG. 2A.


C
Upper Element
Lower Element
D
92
93
94
95
80
82
83
84
85
114
112
104
F
110
102
34
36


200
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Timer: On/Off
12:00
Am
Pm
MODE:
Vacation
Off Peak #1
Off Peak #2
Off Peak #3
Normal
Sun Mon Tue Wen Thu Fri Sat
Select/Program
Timer On/Off
206
204
202
E
UPPER
LOWER
TIMER
LIMIT

Fig. 4.